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ABSTRACT

The approach to topographic map production has been highly organized and systematic with respect to scale, projection, grid, etc., so that the user can expect a high degree of locational accuracy. Less attention has been given by cartographers to symbolic information yielded by the map. Symbolization (information reduction) is required at all levels --including that of the survey. A number of factors should be considered in order to clarify what aspect of the feature the symbol is to concentrate on and what is being omitted, so that there is a clear identification of what the symbol is intended to convey to the user. If cartographic symbols can be devised to convey specific attributes of represented features, two other considerations emerge --the graphic structure of the symbols, and the way the user responds to them. If premises are acceptable, the following conclusions can be drawn: 1) design of map symbols cannot be isolated from data collecting; 2) if informational content of maps is be increased and improved, there cannot be heavy reliance on photo-interpretation; 3) a more deliberate and systematic attitude about manipulation of graphic image will be necessary to make the map a more effective communication; 4) present interest in a digital form of map information makes sense only if equivalent standards can be applied and maintained. (JLB)

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A SYMPOSIUM ON THE INFLUENCE OF THE MAP USER ON MAP DESIGN

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SYMBOLS AND MEANING IN TOPOGRAPHIC MAPS:
some limitations due to aspects of map design.

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The Nature of Map Information

Basically the information in a topographic map contains the answers to two questions: "where?" and "what?". The answer to the question "where?" is of course location, and this is the primary information of a map and the essential reason for its use. All other information about features can be expressed as well or better by other means. The long and continued use of maps is founded on this property, that the ordered, scaled two-dimensional structure of the map is the most effective means of recording and communicating locational information. This applies of course not only to visible topographic features, but also to all those which are defined by or can be referred to the earth's surface. And as this is the most important plane of human existence and activity, it is natural that we define location in relation to it.

This definition of location is both absolute and relative. It is absolute because a topographic map provides a structure which can express location in absolute terms in relation to the earth's surface, and this structure can be applied universally. It enables any point or distribution on the earth's surface to be defined without confusion or ambiguity. It is also relative because the information for whole areas is provided simultaneously, and therefore one location or feature can be identified in relation to others which are adjacent to it. In fact, for most map users, this is the commonest way of identifying location, or establishing "where is it?".

Because of this the providers of basic information, the surveyors and photogrammetrists, have concentrated on the principle of accuracy of location; of precision in planimetry and height. This informational aspect of the map is well developed, and is the subject of considerable scientific knowledge and technical efficiency. Unfortunately, the emphasis on this aspect seems at times to be so great that it can be inferred that this is the only aspect for which exact information is required, or is even considered to be necessary. Topographic maps today are produced to standards in which the map user can have confidence. In a way, this is as it should be, because until this stage of development had been reached, any other question regarding accuracy in maps was relatively unimportant. But now that we are in a position to produce a variety of maps which are 'accurate' in this sense, it is perhaps desirable to consider whether 'accuracy' for the map user does not have a wider meaning.

Information and Symbols

The main point of this discussion, therefore, is not concerned with information about location, but with the more complex and tenuous problem of what other information the symbol contains. Any map shows that something - real or abstract - has a certain location, ground area, and/or distribution. The question remains, what else is included in order to describe the feature to the user?

I am not supposing that this is an entirely new question, that cartographers have not enquired into it, or that modern maps do not show any examination of the problem. Obviously it must be answered on some level if the map is to be constructed at all. But deeper examination shows that the degree of organisation of this aspect of symbol information is much more variable, less carefully defined, and often more confusing to the user than the organisation of information about location. Is it possible, therefore, to extend our understanding of how this other information is identified, collected and represented, in order that the definition of 'accuracy' can be extended to include all the map information?

As a means of investigating this, I propose to advance two hypotheses. First, that for any feature, only a selection of the total information which describes it is shown by the map symbol: second, that the function of the symbol is mainly to classify or categorise; that is, those features which have certain characteristics in common are grouped together, even though they all have individual differences, and even though they all have different locations.

The first of these is important, and not always appreciated. Even on a large-scale map or plan, which is sometimes described as having 'little or no symbolisation', and which is devoted primarily to representing buildings or the artificial structures of the built environment, the content of the map is highly selective. The main point of emphasis is division at ground level, generally ignoring entirely the three-dimensional structure of buildings, and even the three-dimensional surface of the earth. Sometimes the constructional material is defined, but not often; and on occasions a limited degree of function or use is also included, such as the distinction between public and private buildings. As this highly-selective information is what the surveyor surveys, I hope that it is also clear that the informational content of the map arises principally from the basic decisions about survey, and is not a separate element added by the cartographer, because it is not possible to consider the creation of symbols apart from the available information about the features being represented. On such a basis there may be no evidence in the map to distinguish between a large timber bungalow and a four-storey concrete block: if in many cases the distinction can be made, it is only because the user has sufficient reference background to make the interpretation, and not because the information itself is contained within the map. It is important to be clear about this when considering the relationship between the map information and the map user. Frequently the cartographer knows what he is doing, and accepts it without consideration, but if we are to examine the contact between map maker and map user, then we have to be conscious of this point.

There are of course good reasons why the large-scale topographic plan is constructed in this manner. Divisions at ground level are of basic importance in the human environment: they provide the most evident features, in particular the obstacles to movement and the position of recognisable entities. The point I am making

here is that far from being a 'picture of the earth' the map is a highly abstracted selection, and if the user is not aware of the implications of this he is likely to fail to deduct correctly the information presented, or be vaguely dissatisfied because he is expecting the map to present other information. In many cases, when non-cartographic users are consulted about map content, the cartographic difficulty is to explain why it is that some information can be effectively included in the map, and other types of information cannot. This problem cannot be resolved unless the map-maker is quite clear about all the informational aspects, and the reasons for including some and not others. To put this another way, if such a plan could be shown to a person who had never seen an urban environment, he could be completely unresponsive to the pattern of line symbols; and the origin of this situation lies in the selectivity of map information.

The second point is also widely understood, but again it is necessary to examine the full implications. To take the large-scale example again, a particular individual feature may be represented by a single point symbol; for example each tree may be indicated by a small representation of a tree. This symbol will show its location, its major physical characteristic as a tree in the sense of its appearance, and possibly some indication of its relative size. But the main function of the symbol here is not only to identify the individual feature in its true location, but also to relate it to other features of similar type: in other words, to place it in a specific category. Depending on the scale of the map, the complexity of the features, and their significance to Man, these categories may be very extensive and inclusive, or they may be very intensive and exclusive. The photomap only does this obliquely and at random: the degree of relationship between one feature and another one of similar character depends wholly on the partly-accidental or coincidental fact that the different individual features happen to produce the same reaction in the photographic emulsion, due to their visual characteristics in relation to light at the time. In this case the informational clues which enable the user to sort out groups of like things occur possibly at random in the photograph, and will be different under different conditions of light, and with different emulsion characteristics. The function of such things as colour and false-colour photography is to provide a more substantial set of clues, the purpose of which is to identify those items which have some definable characteristic in common. It is this function of categorisation or classification which is fundamental to the map and its symbolisation, and it operates at all scales and with all map types. The total amount of information in the map will therefore depend principally on the degree to which this categorisation is carried out: in other words, the extent to which specific sub-categories are formed.

The main point of this argument which I want to elaborate is to consider whether this process can be formally defined, in order that the cartographer can be fully conscious of exactly what information he is presenting, and so that the discussion about content and

information between map-maker and map-user can be advanced from generalities to specific issues.

Abstraction and Generalisation

The principal clue to this problem is the nature of abstraction as a mental process, and its relationship to generalisation. In cartography the term generalisation is taken to refer to the process of information reduction: that is the expression of detailed by less detailed information, by selection, omission, and simplification. In my opinion, this is the key to the whole process of symbolisation, and I would extend its meaning to include the entire operation of selecting information and deciding how to show it, including the decisions at the basic survey stage. I realise that many will disagree with this point of view, and so I will present my reasons for it.

On the map there must be enough information to distinguish one group of features, which have something in common, from all others which do not have these characteristics. For example, roads are shown by single or double lines, with or without colour fill, and these clearly separate these features from all others. At the same time, different sub-categories of road are distinguished one from another. The information about 'road' in its most general sense, is refined in order to give the user specific information about different types of road, because this is important to him. This takes place on the basis that the very general term 'road' is not very informative: a large number of different occurrences must be gathered into this category, and as they vary so much in function, from a human point of view, it is necessary to abstract some characteristics which some roads have, and others do not. So within the broad category, some particular qualities or quantities are used which enable the cartographer to separate certain types of road from the whole group, and represent these separately. If a smaller-scale map is derived from the large-scale one, then the generalisation process proceeds to replace these sub-categories by other and more extensive groups, which are not divided from each other by the same differences. In other words, the process is not a straight reversal, that is the replacement of x categories of road by only one, but involves a qualitative shift, because in order to make the general road categories at smaller scale, a different set of factors will be involved as a basis for the generalisation. At the large scale, the surveyor 'abstracts' from the total information about the feature, the information needed to define the main categories, and also to sub-divide these more effectively into smaller groups. At smaller scales, the cartographer takes this and other information, and 'generalises' these detailed road categories into a small number of more extensive groups. Therefore, this process of abstraction and generalisation operates at all levels, and frequently it is done by the surveyor, although I doubt if the surveyor is aware of it. This of course raises another problem of the collection of information and its representation, implicit in any operation which selects certain types of information and not others, but perhaps this can be pursued in discussion.

If for the moment we accept that this process of abstraction takes place in all map-making operations, then we proceed logically to the critical question - on what basis does it take place? In effect, what are the characteristics which are abstracted in order to construct different sub-categories within the same group?

Factors in Classification

In order to provide a systematic approach to this categorisation of features, I have attempted to list a number of factors which are relevant to an analysis of possible attributes, as a basis for considering what specific information is relevant in any particular case. This list is tentative, and cannot be considered as exhaustive. It is most likely that a different set of factors would apply for maps of different subject-matter and of different geographic environments. Even so, it is sufficient at this stage to demonstrate the point. Much of it is obvious, but the object is to cover all the possible factors. Working from the general to the particular, these are all aspects of topographic features which could be examined in order to decide what characteristics might be used to distinguish one category from another.

1. Basic type.
2. Composition.
3. Dimensions.
4. Appearance.
5. Mode of occurrence.
6. Permanence.
7. Availability.
8. Present state or condition.
9. Function.
10. Significance or value.

These factors will include most of the points which have to be considered in order to clarify what aspects the symbol will have to concentrate on, and what is being ignored or omitted. If we examine these headings, with some examples, in relation to the types of features represented on maps, then I hope to illustrate the basis of deliberate practice in the construction of symbols, which at the same time is concerned with the real nature of user requirement.

1. Basic Type

The selection of major elements of the topography, and their assignment to a certain colour, or 'plate' is so much a part of standard cartographic practice that it would hardly seem worth mentioning. Examination of different maps will reveal, however, that it is not always followed, and that there are many situations in which particular symbols seem to have been introduced more as an afterthought than as part of a system. It is therefore a necessary basic concept, and needs to be pursued logically if the map representation is to be systematic. The distinction between major elements, such as land and water, is basic: but in this case

it is necessary that if hue is to be used as the basic visual distinction, then it should be followed through. Some more difficult problems occur where there are 'mixtures' - for example, proportions of water, land and vegetation. The degree of predominance of land or water needs to be carefully considered when the particular symbol is devised.

Perhaps the more significant aspect which is raised in considering basic type, is the question of the extent to which the topographic map ought to categorise or classify all the topographic surface on the basis of its major characteristics. In this respect practice varies a good deal. From the user's point of view, does blank space on the map indicate 'no information' or 'no description'? If certain elements of the land surface, such as its basic composition in the terms of rock, sand, soil, vegetal covering, built-up areas, are included, is there a tendency for the user to assume that this analysis has been consistently applied? It is here that the selectivity of map content is quite apparent to the cartographer but not necessarily apparent to the user. The reasons for this selectivity are complex, and considerably affected by tradition and the methods used in map construction. From the surveyor's or photogrammetrist's point of view, finite and discrete elements are much easier to deal with than areas characterised by the random mixture of different minor features. Variations in distribution of small surface features are certainly the most difficult things to delimit and 'measure'. Historically it is clear that the topographic features most likely to be included were definite features which served either as landmarks or as obstacles to movement. Forests come into this category, and as such appear on virtually all topographic maps. But this inclusion and characterisation of vegetation tends to stop short whenever the vegetal forms are small in size, even though they may be of great importance in characterising the landscape. Much photo-interpretation is concerned with the analysis of landscape features 'missed' by the topographic map content, but must we assume that the topographic map cannot deal with this aspect of the surface more effectively? Some of the effort quite deliberately expended on photomaps - and acceptable because a new form of product is involved - would not be wasted on applying some of the same process to topographic map content. It is generally possible to assign all parts of the area at least to some basic type, and thereby to categorise the entire surface. This may be 'generalised' but no more so than much of the other map content which is traditionally accepted.

In some cases, such as the Ordnance Survey One Inch of the United Kingdom, only the exceptional is represented, so far as type of land surface is concerned. That is, rock areas, wooded areas, etc., are represented: if there is no symbol then the user is expected to realise that there is some sort of cultivated or improved land present. To my knowledge, this fact is not brought to the attention of the user. In effect it means that the negative information approach is only possible provided that it can be assumed

that the user is sufficiently well acquainted with the geographical environment, and therefore has the required 'reference background'. But it is a dangerous principle if 'exported' to quite different geographical environments. It also has a strong influence on the design and appearance of the map itself. The Swiss 1:25,000 is a delightful and satisfying cartographic product not only because of the subtlety and refinement of its symbol design, but because it has the unity which comes from categorising all parts of the surface, and therefore providing a continuous representation of the topography.

2. Composition

This can apply not only to the materials from which things are constructed, such as timber or masonry, but also such things as salinity of water. In many regions there are important differences in the qualities and characteristics of water, and where this is limited they can be of great importance for both population and agriculture. Although the general category 'water' may seem to be adequate, and the distinction between fresh and salt simply inferred from other map information, there are many situations where it needs to be further refined, in order to devise suitable distinctions or categories.

3. Dimensions

This term can include all those dimensions or even evaluations which refer to the absolute or relative size of the feature. For obvious reasons, ground plan is usually taken without question. But there are other measurable quantities which can be just as or more significant. Height, volume, rate of flow, number of storeys, may be more important factors than plan dimensions in the case of particular features. This is recognised on some aeronautical charts, where high constructions are represented by profiles to aid in their recognition and identification. This of course is a subject of considerable variation if seen in relation to the whole of cartographic history. Two or three centuries ago it seemed very normal to cartographers to show towns and great houses as three-dimensional objects, in which elevation was more important than true extent. The diminution of this point of view is a mixed blessing. It is true that it can be difficult to measure height of feature exactly, but in many cases even an approximation would give the map user a much greater sense of what to expect, and could be used as primary information in devising a suitable symbol. Classification by degree, into large and small, or major and minor, can also be included here.

There are many other cases where 'size' is not necessarily related to area. A most important well or spring may be a very small feature on the ground: its importance is a function of volume, or rate of flow, or consistency of flow, or purity of water. A 'large' tree may be a very tall one or one with a great diameter. There are many situations where dimension plays an important part in considering which characteristic to abstract in order to provide

the user with the most significant information. What I am suggesting here is that in thinking of dimensions, it is often desirable to go beyond the simple fact of plan extent, and consider the feature in all its aspects before coming to a decision.

4. Appearance

This embraces the characteristic shape, structure, and colour of the feature, either individually or collectively. It is usually closely allied to the basic map categories through colour assocation, real or imaginary. It lies behind many attempts at 'realistic' representation, whether this involves the construction of point symbols for single features, or point symbols used in distributional patterns. The traditional 'marsh' symbol, the distinction between deciduous and coniferous trees, are obvious examples. It is highly important in all landmark features, and clearly should be taken into account when the form of the symbol is being designed.

5. Mode of Occurrence

This is not a very satisfactory term, and is intended to express an aspect of distribution. When an area is characterised by the repetition of individual forms, then both regularity and density of distribution may be taken into account. Density in vegetation may range from continuous cover to sparse; the distribution may be regular or irregular. As tall vegetation is one of the major obstacles to movement, then the distinction between forest which is impenetrable, or virtually so, and forest which is sufficiently open to walk through, can be important. It is a factor which often has to be accepted in military terrain analyses.

6. Permanence

The graphic image of the map is finite, and cannot itself deal effectively with changes in time, or variations over a period. Many features which are shown as having a fixed position or regular occurrence on the map are not really so. This may be generally understood by the map user, but only to the extent that he is aware of the geographical characteristics of the region. Some lines, such as coastlines and shorelines, usually express mean values; others represent average or normal conditions. In devising the symbol for a feature, it is worth considering the extent to which the symbol adequately informs the user about possible variations in occurrence and position, and whether perhaps a sub-class should be defined because of its marked variation or instability. This commonly arises in relation to water, both water bodies and drainage systems. Where water supplies may be limited, land seasonally flooded, or rivers dry for long periods, the fluctuation characteristic is too important to be ignored.

7. Availability

The physical presence of an object does not necessarily mean

that it is in use, or even open to approach. Some natural features are seasonally limited (wells and water-holes); some areas are restricted for one reason or another (private roads on estates, military prohibited zones). The same factor can be more broadly interpreted to cover situations which limit the apparent function of a feature. For example, the presence of a road implies the possibility of communication; but this may be limited by gradient, snow, avalanche danger, narrow bridges, etc. The simple solution of accepting the principle that the map records only what can be identified on the ground at a certain time does not really hold up in practice, because this would exclude many features which are regarded as integral parts of topographic maps. As features are both selected and characterised from the point of view of Man's occupance of the land, then conditions which clearly affect such things as movement should also be taken into account.

8. Present State or Condition

This may be only a sub-category of (7), but there are major and long-term variations as well as seasonal or limited ones. This may result in a change in appearance (ruined building), or of function (abandoned railway); forest may be burned over; a road under construction. These are in fact major departures from the normal or expected conditions.

9. Function

This factor is used to cover all the ways in which things are identified by the way in which they are used, entirely or in part. In some cases this may be the principle criterion for inclusion in map content, and may be the basis for representation. It is most applied to point locations at medium and small scale, often to the use of buildings and other constructions. A cross representing a church, crossed hammers for a mine, an anchor for a safe harbour, an electricity symbol for a power station, are all obvious examples. It can be highly important, because it may identify the nature and expected appearance of the object for the map user better than any other abstraction of possible descriptions. Features comprising many different varieties can sometimes be sorted out more aptly on this basis than by any other characteristic.

10. Significance

This is a complex factor, which may only be an assessment of the previous ones, but in many cases does take place on the basis of other evidence. In operation it frequently over-rides physical dimensions. For example, small buildings in sparsely-inhabited areas will continue to be represented, even with exaggeration, long after physical features of the same size have been omitted. Significance may be based on qualitative or quantitative factors, derived independently from other information. The grading or classifying of roads by provincial or national authorities: the use of population statistics in judging the relative 'size' of

inhabited places: the inclusion of very small localities because they are of economic importance; these are all used to qualify the apparent evidence of the other factors. The distinction between natural and plantation vegetation is usually on the basis that one is more important to Man than the other. The role of boundaries in different hierarchies often bears little relationship to evidence on the ground, and their symbolisation is almost entirely a matter of a judgement of their significance.

Many of these factors overlap to some degree. This list is not all-embracing, although it is possible that it could be made so in practice. Primarily it serves as an example of a deliberate approach to the consideration of the specific types of information which may be sought in order to identify more clearly what it is that the symbol is intended to convey to the user.

To follow this line of reasoning in more concrete terms, an example of a 'point' feature may be taken in illustration. In many parts of the world, the supply of water is limited. Where supplies of surface water are inadequate, then reserves of ground water may be of critical importance for settlement and economic activity. The water-hole may consist of a natural pool, a pool fed by a spring, or a well reaching down to the water-table. The simple approach is to locate such features and represent them as part of the map content, often by a small blue circle. From the map user's point of view this very general categorisation may be of limited value, because it is lacking in specific information. Several further abstractions about these features can be made, if the possible factors are considered. Is the water suitable for human consumption? - it may be too brackish or saline. Is the supply regular, or seasonally limited? Is some dimension of volume important - that is should a 'large' water-hole be distinguished even though it may be no bigger in ground area than another? Is it generally available, or does it have to be drawn or pumped up? Is it accessible, or is it the exclusive preserve of some group of people?

Some of these questions may be irrelevant, and some may introduce aspects which greater knowledge of the terrain would easily dismiss. But asking such a series of questions would be a useful preliminary in deciding deliberately whether one simple and all-embracing category would suffice, or whether the nature of the feature is sufficiently complex to justify further categorisation. Such an examination also pre-supposes that any decisions regarding the mapping of this feature will be incorporated into the survey specification or the field check. It may transpire that the information would be too costly to collect in relation to its significance; but if this is the case it is the result of deliberate decision, not ignorance, and the explanation of symbols can then draw attention to the fact that the feature represented includes a number of variations. In other words, the unqualified general category indicates a degree of uniformity or simplicity which may be far from the truth. Unless this is stated, the user has no means of distinguishing between lack of information, ommission of information, and the terms of symbolisation.

In addition, at the planning stage it might lead the cartographer to ask pertinent questions of those representing the actual or potential map user. It may be argued in theory that the consumer should provide these indications himself; but in practice a precise definition about all map content is only likely if the cartographer pursues the full definition of the content in detail. At the same time it obviously suggests that it is pointless to regard symbolisation as an entirely separate operation which takes place only after the data has been collected. The communication between surveyor and cartographer, by whatever means, is something which has to be established at the outset. If the map makers collectively are not clear as to what the information in the map is really about, then it is unlikely that the map user will be.

Meaning and Graphic Representation

If it is agreed that cartographic symbols can be devised so that they inform the map user about specific attributes of the features being represented, then two parallel problems emerge. The first concerns the graphic structure of the symbols themselves; the second concerns the way in which the user responds to them. If the map is to serve as a means of communication effectively, then there must be some relationship between these two.

In constructing the graphic forms of the symbols there are certain limited possibilities. The symbols must be perceptibly different, in order that they can be distinguished; that is the user must be able to discriminate between them. At the same time, going back to the original definition of the relation between symbols and feature categories, similar things or divisions of the same basic feature should be shown to be similar. This involves expressing relationship. There are widely-known rules or precepts relating to both these aspects. For example, hue is used to denote a major category; other graphic variations such as modifications of the hue can be introduced to define sub-categories within the larger one. Size variations are related to sub-class based on importance. Variations in form for point or line symbols are introduced in order to provide a group of different but related features. The total cartographic vocabulary is therefore composed of colour (hue, saturation, brightness and texture), dimensions (line gauge, point symbol size) and form (continuous or discontinuous line, square or triangle). Because of the large number of different features, or categories of feature, included in topographic maps, the same or apparently similar graphic forms have to be used to cover a wide range of information.

This can best be illustrated by considering the use of the line in representation. On any one map it can represent many different things. Although the distinction between the line as a linear feature, and a line as a boundary or edge is commonly recognised, the situation is really more complicated than this. A single continuous line can indicate at least five different things: (1) an edge or outline, indicating a change in surface;

(2) a linear feature on the ground, such as a river or road; (3) an invisible feature such as a boundary; this acts basically as (1) but it also has three-dimensional implications, because it may include a division both underground and in the airspace; (4) a mean value, such as a coastline, which represents a zone of fluctuation according to some principle; (5) a metric abstraction, such as a contour, which has no 'real' existence, but serves to indicate variations in a surface, by abstracting certain lines of a common value. It could also be argued that such a line is an abstraction from the totality of points which represent the whole surface, all of which gave an elevation value, and that this in itself is a form of categorisation or classification. The fact remains that graphically none of these basic differences are conveyed to the map user, and he understands them only to the extent that he is or may become familiar with map structure. But even the experienced map user can be misinformed about the information, unless the basis for the symbol design is defined in some way.

The basic question here is whether the design of symbols must attempt to be systematic, or whether it is sufficient to rely on a simple statement of equivalence; that is, that symbol of appearance A is equal to a defined category A, as explained in the legend. The latter is expressed by the phrase 'conventional sign' by which the map user equates a given description with an arbitrary graphic form. This is the vocabulary or dictionary approach. The ultimate outcome of this, if logically applied, is the formation of a complete set of standardised symbols, a universal dictionary, which the map user learns to use, and by which he can relate a particular meaning to a particular graphic form.

Although there have been attempts in this direction, at least in limited ways, and although it would appear to be a straightforward solution to the problem, it can never be successful for a number of reasons. In any one map design, the relationship between symbols, in particular their visual emphasis, is as important in legibility as their individual clarity. Secondly, maps are used not only to identify individual things, but also to present their distributions. And third, what is geographically important in one region may have a quite different importance in another. An image as complex as a map cannot be ordered on the basis of any one simple rule.

Symbols and the Perceptual Process

If the conventional sign approach is inadequate, are there any other possibilities? To look for a possible answer, or even a clue to an answer, it is desirable to enquire more closely into the method by which the map user extracts information from the map; that is, how he deduces meaning from the graphic forms. Although little is really known about this in relation to maps, it is worth trying to apply some of the basic principles of perceptual psychology, at least to attempt to identify the problem.

At present most of the development of perceptual psychology has been towards the investigation of the ways in which senses are stimulated to responses within the enormous variations of the environment. Theories which have to encompass wide ranges in situation and behaviour must concern themselves with the general. The lack of immediate applicability of the results or present conclusions to map use situations is not really surprising when the very specialised nature of map information is concerned. Even so, some exploration of the elementary conclusions about visual response may clarify the map use problem.

The map consists of a series of graphic images, displayed simultaneously within a metrical framework. The geographical distribution can occur in any arrangement, and therefore it is not possible to impose any arbitrary pattern, as may be done in any fine art composition. At the same time the user may be searching for a single item of information, or an appreciation involving the relative assessment of many items of information. It is clear that the complexities of this are not understood, but if for the moment the simple situation of the search for an individual item is considered, then the pattern of the response activity can be described as follows.

The first stage is detection: the user must be able to see the symbols, that is they must be visually evident. This is the minimum threshold of legibility. In the second place, some discrimination between the various symbol stimuli must take place, in order that the symbol at one place is seen to be different from, even if related to, a symbol at another place. Given these two conditions, then perception is completed either by recognition, or by identification, or possibly both.

Using these terms specifically is important to separating the two types of reaction. With recognition, the symbol on the map is matched with, or compared with, a certain limited number of known possibilities, and the correct one selected. In the map case, this set of possibilities is the total legend, or explanation of symbols, which the user has either consulted or can consult. If recognition is to take place immediately, or quickly, then the user must be experienced and must carry a set of reference images in his memory. The effect of this can be seen in many habits with regard to the construction and use of maps: the policy of limiting the range of symbols, the resistance of those accustomed to certain conventions to have them changed, the belief that certain features 'must' be represented in certain ways. The system relies on the use of a graphic vocabulary, as referred to previously. In the other situation, the user identifies a certain symbol by matching the stimulus with his own set of possibilities or alternatives, that is against some mental concept of the nature of the object for which he is looking. That is, he seeks to relate the attributes of the feature to the attributes of the stimulus provided by the graphic image. Therefore, when looking for some water feature, he will be consciously or unconsciously seeking features shown in blue,

because he associates this with a characteristic of the feature being sought. Whereas the ultimate end of the recognition situation is a complete dictionary, the end of the identification situation is the construction of a grammar; that is a systematic use of the attributes of symbols to particular meanings which identify the features.

In practice it is unlikely that either of these situations exists independently, or that any map user relies wholly on one or the other. The map exclusively designed for the identification process would have to be readable without any explanation; that is the symbols would have to be self-evident within the rules of the grammar. In many cases the user begins with identification - that is he quickly perceives that brown lines always represent contours, not only because of the line colour but also because they have particular form characteristics which he can identify in relation to variations in the land surface: but if he comes up against some symbol which he cannot 'place' he may retreat into recognition and consult the list of 'alternatives' until he finds the one which matches.

Whereas recognition can be adequate for the understanding of particular items, it fails completely in situations where the pattern of distribution is involved. This is the basic reason for 'map interpretation' as a subject of study. Anyone can learn that a black square represents a building, and recognise the black squares on the map as individual items. But the appreciation of pattern within the distribution of black squares, and their relationship with other distributions cannot be expressed by the items of the legend. It is in these situations that similarities or links between symbols, as well as discrimination between them, become important in identification.

If this 'sorting out' of particular characteristics of features is applied, and if there is a deliberate attempt to use the same graphic device in similar situations, then instead of relying on memory for recognition the map user would gradually acquire an understanding of the grammar. Instead of looking in vague and general terms for some information, without any comprehension of what he might expect to find, he would search the symbols on the basis of colour, dimension and shape, expecting to be able to relate specific pieces of information to each perceptible difference. When confronted by a continuous line symbol, his reaction would be "either this represents a continuous feature on the ground, or it is a continuous line of measurements, or it is an absolute limit of some sort". If adjacent to this he detects a similar but thinner line, his reaction would be "this is the same sort of thing but has a lower value, or belongs to a less important group". If the next symbol was of the same colour and thickness but in discontinuous form, his reaction would be "this is to a lower standard, it is based on fewer measurements, it may be only an approximation, or its significance has been seriously reduced for some reason". The distinction between those items of information which had been fully

defined and those which had been approximated would be clear from the graphic images themselves.

Conclusion

This investigation is intended to arouse discussion of the basic informational content of the topographic map, rather than to provide a specific solution to any limited problem. If the premises are acceptable, then the following conclusions can be drawn.

1. The design of map symbols is an integral part of the formation of the map, and cannot be satisfactorily achieved in isolation from the data collecting stages. It implies a closer association at an early stage between survey and cartographic planning.

2. If the informational content of the map is to be increased in quantity and quality, then the present tendency to rely almost entirely on photo-interpretation, which depends so largely on visible characteristics, will need to be resisted. Although this procedure is of enormous importance in both speeding up and making more consistent the compilation of map detail, there is a constant risk that the information so gathered will be of limited value because it does not provide a suitable basis for the formation of proper sub-categories.

3. In making the map more effective as a means of communication, the role played by the user must be understood not only in general terms of 'requirement' but more specifically by giving the user the same elementary set of rules about the graphic image as can be used by the cartographer. This will involve a more deliberate and systematic attitude by the cartographer to the manipulation of the graphic image, so that the structure of the map as a whole becomes more apparent.

4. The question of 'accuracy' in a map is not only a matter of scale, position and measurement in plan and height. The map can only be 'accurate' if all the information is specified, and if in turn this information is passed on to the user. Most modern map series have become much better defined as regards the metrical information: scale, projection, grid, type of survey, etc. are normally indicated in the margin of each sheet. The same sort of approach must be attempted with the other map information, before a real assessment of 'accuracy' can be made.

5. The present passion for converting map information into digital form, often at great expense, only makes sense if we are quite sure that this information is really what it may appear to be, and there is some concept of its real informational value. The growing ability to handle large amounts of information does not necessarily mean that we will be any better informed

in the future - only that we will be more informed. The map, by its very nature, demands selection from the total information available. Instead of regarding this as some sort of informational handicap, it might be wiser to appreciate that in the very process of inspecting the topography carefully to decide on what should be included, there is the opportunity at least to concentrate on the most important aspects; and that the final quality of the information, from the user's point of view, largely depends on how carefully this is done.